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HYPERPLASIA OF BRUNNER'S GLANDS

A. A. EPSTEIN, M.D., C.M.
and
L. J. COLE, M.D.
Toronto, Ontario

To our knowledge, only three cases of hyperplasia of Brunner's Glands have appeared in the literature up to 1953. The first of these was reported by Erb and Johnson[1], and the next two by Dodd, Fishler and Park[2]. These two cases were diagnosed clinically, and in one, the diagnosis was confirmed by operation and pathological examination of the resected specimen.

In the past year, we have encountered a similar case. The diagnosis here was made on the basis of roentgen examination using criteria advanced in the excellent review of the condition by Dodd, Fishler and Park. The rarity of the condition would, we believe, warrant reporting an additional proven case.

Case Report

S.B. — A 52 year-old white, male merchant presented himself on the 30th of September, 1953, with a six-year story of epigastric cramps, bloating, belching and heartburn coming on immediately or two hours after meals. These were relieved by spontaneous or induced vomiting, the vomitus frequently containing undigested food but no blood or bile. During the previous seven months these symptoms had become worse and were associated with low dorsal backache.

The past history was not contributory.

The essential findings on examination were a weight loss of ten pounds, slight epigastric tenderness and a succussion splash over the stomach. The urine was negative, hemogram normal, blood serology negative and the stool negative for occult blood. Gastric analysis disclosed moderate hypersecretion with hyperacidity rising to 70/75 units in one hour, but was otherwise normal.

A chest roentgenogram disclosed a tiny calcification at the right apex but was otherwise not remarkable. X-ray studies revealed a normal gall bladder and the gastro-intestinal series disclosed a polypoid appearance of the duodenal caput. (Figs. 1-2-3.)

On an ulcer regimen, the patient exhibited only transitory improvement. The repeated gastro-intestinal series one month later showed no change in the appearance of the duodenal caput.

The patient was hospitalized at the New Mount Sinai Hospital, Toronto, on the 17th of January, 1954 and underwent abdominal exploration on the 20th of January, 1954. At operation the pertinent findings were con-

Figure 1. Conventional film of stomach in left anterior oblique position. Note ragged appearance of duodenum without compression.

Figure 2. Conventional film of stomach revealing polypoidal defects involving the duodenum and extending into the descending limb.

Figure 3. Spot pressure film revealing typical "Swiss Cheese" pattern of duodenal cap.

fined to the first portion of the duodenum. Here there were a few external adhesions and the bowel felt unusually thickened. Duodenotomy and gastrotomy showed the duodenal mucosa to be heaped up and to almost obliterate the duodenal lumen. This opening was closed and an anterior gastro-enterostomy and abdominal vagotomy were carried out. The patient tolerated the procedure well and had a fairly smooth post-operative course except for a transitory episode of stomal edema requiring gastric suction and replacement of fluid and electrolytes.

PATHOLOGICAL REPORT

Gross Description

1. The biopsy from the duodenum submitted for quick section consists of a nodule of tissue which measures 1.2 cms. in greatest diameter. The outer surface is of mottled pinkish and reddish color. The cut surface is light pinkish and finely granular.

Quick Section Diagnosis:

Hyperplasia of Brunner's Glands. No evidence of malignancy.

2. The second biopsy from the duodenum measures 2.2 cms. in greatest diameter. It is pinkish in color, mottled with brown, and is covered by an epithelium of some sort which is quite soft. The cut surface is light pink and finely granular and shows a great deal of hemorrhage to be present.

3. The biopsy from the stomach measures 1.9 cms. in greatest diameter. It is quite soft and is covered by a pinkish epithelium of some sort, which is quite granular. On the cut surface the epithelium is seen to be light pink and finely granular and the underlying tissue of a darker pink color and also granular.

4. The specimen from the vagus nerve consists of two cord-like strands of tissue, the longer of which measures 1.5 cms. in greatest diameter. The outer surfaces are pinkish and somewhat glistening. The cut surfaces are pinkish and finely granular and have running down their centres a still thinner cord-like structure.

Microscopic Description

1. A number of sections of the specimen from the duodenum were made and examined.

Orientation is somewhat difficult. The specimen is seen to be made up of numerous lobules of typical Brunner's Glands. These lobules are separated from each other by thin strands of fibrous connective tissue. The lobules are increased in number and size. A few lymphoid foci are evident. There is no evidence of malignancy.

2. This specimen is seen to be made up in part of typical gastric mucosa and in part of duodenal mucosa. Here again there are numerous lobules of Brunner's Glands present. There are a number of lymphoid follicles to be seen. In the underlying stroma there is much recent hemorrhage present.

3. Sections of this specimen show it to consist of typical gastric mucosa and submucosa. The occasional focus of lymphoid tissue is seen to be present. There is no evidence of ulceration or neoplasm.

4. A number of sections of this specimen were made and examined. It is seen to consist of fibrous connective tissue and a number of non-medullated nerve fibres are present.

Final Diagnosis:

1. Hyperplasia of Brunner's Glands (duodenum).
2. and 3. Chronic gastritis, slight.
4. Non-medullated nerve fibres - - No pathological diagnosis.

Discussion

The "duodenal glands" were first completely described by Brunner in 1687 and again in 1715. These glands are compound tubular in type, and are located in the mucosa and submucosa[3]. Their exact distribution varies considerably. Generally they are most numerous in the first part of the duodenum and become less frequent and finally disappear in its more distal parts. They may, however, extend into the pylorus for a short distance and they have been observed, on occasion, in the first part of the jejunum.

The secretory portions of Brunner's Glands have an alveolar appearance and are confined chiefly to the submucosa. The excretory ducts extend through the muscularis mucosae, and empty into the crypts of Lieberkuhn.

The secretory cells are columnar and resemble those of the pyloric glands and, with suitable stains, can be shown to contain mucigen. The function of these glands appears to be to produce extra mucus at the site where the pancreatic enzymes are emptied into the intestine. This presumably may have a protective effect in cases of hyperacidity.

The roentgen characteristics in this case were practically identical with those in the two cases reported by Dodd et al. There were multiple, sharply-defined, filling defects within the duodenal bulb and extending into the descending limb. These defects were largest and most abundant in the bulb, and presented a typical "Swiss Cheese" pattern. There was no evidence of duodenal ulceration.

In the differential diagnosis one must consider the following: —

1. Benign intraluminal neoplasms of the duodenum produce usually a *solitary*, rounded or lobulated defect. Multiple radiolucencies may be found occasionally due to adenomatous polyps and very rarely to hemangiomas or lipomas. The roentgen demonstration of pedicles and the presence of polyps in other portions of the small bowel, or concomitant gastric polyposis will help to distinguish duodenal mucosal polyps from hypertrophied Brunner's Glands.

2. Duodenitis under certain circumstances can simulate glandular hyperplasia. The characteristic features here are:

(a) Bulbar irritability, with or without spastic deformity;

(b) Inconstancy in size, shape and position of the defects;

(c) Obliteration of the radiolucent shadows by compression;

(d) Regression of the roentgen findings.

All of the above criteria are not present under therapy in hyperplasia.

Summary:

One clinically detected and proven case of hyperplasia of Brunner's Glands is added to the previously reported cases in the literature.

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Acknowledgement

We wish to thank Dr. David Eisen for his kind assistance and co-operation.

BOOKS RECEIVED

Books received are acknowledged in this department, and such acknowledgment must be regarded as a sufficient return for the courtesy of the sender. Selections will be made for review in the interest of our readers and as space permits.

Clinical Roentgenology, Volume Two, by Alfred A. de Lorimier, Henry G. Moehring and John R. Hannan. The Ryerson Press, Toronto, 1954.

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ABERRANT RIGHT SUBCLAVIAN ARTERY *

by

E. A. PETRIE, M.D.

Saint John, New Brunswick

Introduction

An aberrant right subclavian artery is an anomaly that warrants our attention as roentgenologists. It may be asymptomatic but on the other hand it may produce quite severe symptoms. The severity varies according to the degree of compression caused by the anomalous vessel on neighbouring structures, especially œsophagus and trachea. Symptoms vary from mild dysphagia to marked nutritional deficiency. In any case the recognition of an aberrant right subclavian artery is important, if only to prevent some patients from being incorrectly considered psychoneurotic. The recognition of this anomaly is even more important in cases where symptoms are more severe, as in these, it is the first step in initiating proper treatment.

As not very much information on the subject is to be found in text books on diagnostic roentgenology, it might seem reasonable to conclude that an aberrant right subclavian artery is either rare or of little clinical importance. However, neither assumption would be correct. An aberrant right subclavian artery can no longer be considered rare and the subject is now of more than academic interest following recent advances in surgery making treatment possible. That aberrant right subclavian artery is not rare has been shown by a number of early writers describing post-morten findings,[6,9] but only within recent years has the diagnosis been made in the living[2,4,8,13,14,15]. Further proof is now offered in reporting five additional cases found in the living by roentgen methods from 1950 to 1952. All of these were recognized during fluoroscopy.

It is strange that although well known for many years by anatomists and pathologists, the roentgenological diagnosis in the living does not appear to have been made until 1936. As recently as 1945 Copleman[4] in reporting a single case could collect only four others diagnosed during life by roentgen methods. This is odd as the roentgenological appearance is striking and quite typical. The subject is especially important to roentgenologists, for in many of these congenital anomalies the diagnosis can be made only by means of an adequate roentgenological examination [4,13].

In presenting these five cases some of the literature will be reviewed briefly.

Anatomy and Pathology

Irregularities in the development of the major branches of the arch of the aorta are numerous[1]. They have been classified simply by Poynter into three groups:

(a) Branches fewer than normal, as in the occurrence of bi-innominate arteries.

(b) Branches more numerous than normal as in the absence of the innominate and consequent separate origin of both carotid and subclavian arteries.

(c) Branches in abnormal succession . . .[1]

The cases of aberrant right subclavian artery now being reported are obviously examples of group (c). In this anomaly the right subclavian artery takes origin from the extreme left side of the aortic arch beyond the origin of the left subclavian artery. Consequently to reach the right side to supply the right arm with blood it must cross the midline.

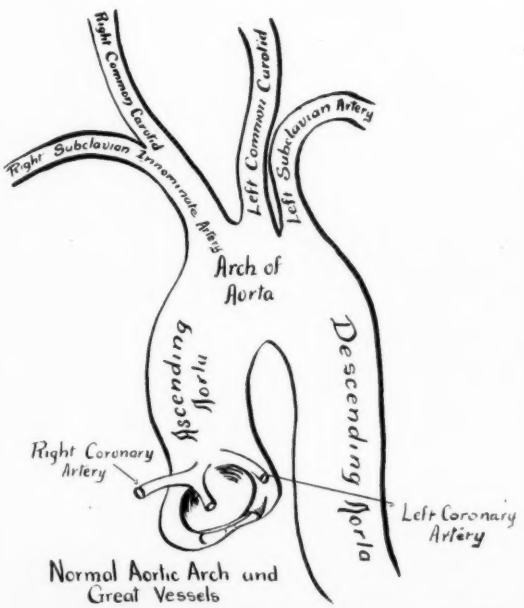

Figure 1. Diagram showing normal aortic arch and great vessels. (After Gray's Anatomy).

Presented at the Annual Meeting, Canadian Association of Radiologists, Toronto, January 28-30, 1953.

In so doing it usually runs between the œsophagus and the spine and this provides the means by which the diagnosis may be made by the roentgenologist in the living by the characteristic pressure defect on the œsophagus posteriorly. (Figs. 1, 2 and 3). Occasionally the anomalous vessel crosses anterior to the œsophagus and rarely even anterior to both œsophagus and trachea.[13] In the large series of anatomical specimens (133) collected by Holzapfel[9] there were 107 cases behind the œsophagus, 20 between the œsophagus and trachea and only 6 in front of both œsophagus and trachea.

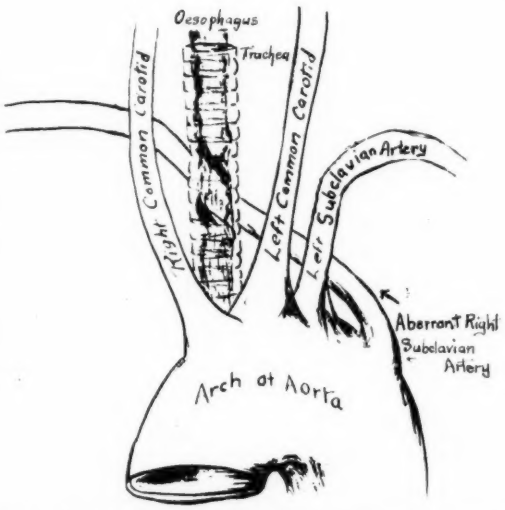

Figure 2. Diagram illustrating course of aberrant right subclavian artery passing behind oesophagus and trachea producing the typical spiral defect.

Figure 3. Case #4, Female, age 43. Aberrant right subclavian artery producing defect in oesophagus just above the aortic arch.

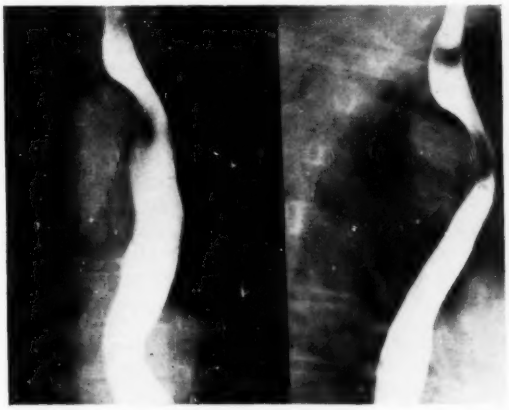

Figure 4. Male, age 57. Posterior type of right aortic arch displacing the oesophagus anteriorly and to the left. This anomaly produces a defect resembling somewhat an aberrant right subclavian artery.

The anomalous artery usually arises from the arch and only rarely from the descending aorta.[4] Its site of origin is most often the posterior aspect of the arch and only rarely the superior wall[4].

Since the site of origin is lower than it normally would be, the aberrant right subclavian artery has to pass upward as well as across, producing the characteristic spiral groove. This crossing may occur anywhere from the level of the sixth cervical vertebra to the fourth thoracic vertebra[4,9,15].

As mentioned above, many other anomalies of the aortic arch and great vessels occur. Their recognition and differentiation has become of some importance, because "with perfection in surgical technique and mastery of the problems of pre-operative and post-operative care, most of these anomalies that are disabling or fatal in their effects are now amenable to surgical cure or improvement"[13]. Gross and Ware[8] give credit to the roentgenologist for presenting a challenge to the surgeon. They express it as follows: "More recently the roentgenologist has provided technique for the recognition of these malformations in the living. It now becomes incumbent upon the surgeon to provide methods of operative relief whenever this might be required and when it appears feasible".

Actually the recognition and treatment of these anomalies of the aortic arch constitutes an interesting and important chapter in the progress of medicine. In the past these anomalies, although well known to anatomists and pathologists had been considered of academic interest only[13], but now this field has become one more example of how the responsibility

of the roentgenologist has increased in medical diagnosis by roentgen methods. The demand for more detailed and precise knowledge in various fields is ever increasing.

It is evident that before discussing the roentgen methods of diagnosing aberrant right subclavian artery it is necessary to have a working knowledge of the various anomalies involving the aortic arch. In articles by Neuhauser[8] and Gross and Ware[2] the following classification of aortic arch anomalies is used as a working basis:

Classification of Aortic Arch Anomalies

1. Right aortic arch:
   - A. Situs inversus viscerum
   - B. Right aortic arch without inversion
     1. Anterior type-arch is anterior to the trachea. Descending aorta is right-sided .
     2. Posterior type-arch passes to the left behind the œsophagus. Descending aorta courses to the right of normal left side position.
        - a. Right aortic arch in which the left subclavian artery arises last from the arch and crosses behind the œsophagus.
        - b. Right aortic arch in which no vessel arising from the arch crosses the midline posterior to the œsophagus. A vessel may pass in front of the trachea.
        - c. Right aortic arch with a persistent left aortic diverticulum giving origin to the left subclavian artery and ligamentum arteriosum.
2. Double aortic arch:
   - A. One aortic limb obliterated.
   - B. Both aortic limbs patent.
3. Anomalous right subclavian artery, arises from the left side of a normal aortic arch and crosses the midline, compressing the œsophagus.
4. Patent ductus arteriosus.

Obviously it is beyond the scope of this paper on aberrant right subclavian artery to discuss at length all these anomalies, but they must be considered in making a differential diagnosis. It is also beyond the scope of this discussion to study in detail the development of the aortic arch system in the embryo. However some knowledge of embryology is essential for the understanding of the pathogenesis of the various anomalies. Thus, it is evident that the roentgenologist must know something about the various aortic arch anomalies that may be present, and should know where to find further detailed information when needed[1,2,4,5,8,12,13,15]. Only three of the more common arch anomalies will be discussed here very briefly, with the exception of an aberrant right subclavian artery. Among the more frequent anomalies are: (1) right aortic arch, usually the posterior type; (2) double aortic arch, and (3) aberrant right subclavian artery.

Probably the best known anomaly arising from variations in the developmental pattern of the aortic arch system is persistent right sided aortic arch[15], long a well-recognized entity roentgenologically, but actually an aberrant right subclavian artery is the most common of all congenital anomalies of the aortic arch[2,13]. The fact that the relatively common aberrant right subclavian artery was not diagnosed by roentgen methods until 1936 is puzzling. It does seen strange that there are comparatively few cases published and that it has been diagnosed in life by roentgenological methods only in recent years[15].

The frequency of these anomalies is very difficult to determine. The following figures are of interest. Holzapfel[9] as early as 1899 had already collected 133 anatomical specimens of aberrant right subclavian artery.

Copleman[4] gives figures from various writers:

> "Anson found 3 cases in 102 laboratory specimens, and Goldbloom discovered 4 specimens among 225 bodies. The incidence in Dolgopol's series was 0.7 percent . . ."

Stauffer and Pote[15] quoting Zdansky state that in a number of series the incidence reported has varied from 0.4 to 2 per cent. The same writers note that "Abbott in her analysis of 1000 cases of congenital heart disease recorded only 7 examples of this condition".

The cause of the development of these congenital anomalies is to-day believed to be German measles or other virus diseases ocurring in the first trimester of pregnancy.

History

The history of aberrant right subclavian artery is interesting. The recognition of an aberrant right subclavian artery goes back to the first part of the 18th century[15]. The first authenticated case is attributed to a post-mortem observation in 1735 by Hunauld[8]. Bayford in 1794 described a case and designated the dysphagia that may result from an

aberrant right subclavian artery anomaly as "dysphagia lusoria", that is *lusus naturæ*, a prank of nature. Incidentally it is to be noted that the name dysphagia lusoria has been applied also to the dysphagia resulting from a right aortic arch[4,15]. As previously mentioned as early as 1899 Holzapfel had collected 133 anatomical specimens of aberrant right subclavian artery, but it was not until 1936 that the first report of antemortem diagnosis appeared. Kommerell[4,15] in 1936 appears to have been first to describe the roentgenological findings. He reported one case. Dahm[4,15] in 1940 reported two cases, Günsel[4,15] in the same year reported one case. These were apparently the first four cases found in vivo. All these appeared in the German literature and it was not until 1945 that the first report appeared in the English literature when Copleman[4] reported a single case and noted the four previous cases just mentioned in which the diagnosis was made during life. A year later, in 1946, Stauffer and Pote[15] reported a single case. In 1947 Brean and Neuhauser[2] reported fifteen cases discovered at Childrens' Hospital in Boston from September 1945 through August 1946 and pointed out the relatively high incidence of co-existent congenital heart disease, particularly anomalies of the cardiac base such as patent ductus arteriosus and the tetralogy of Fallot.

A noteworthy contribution was made in 1946 when a surgical procedure to relieve the dysphagia of anomalous subclavian artery was devised by Gross and Ware and by 1947 this had been successfully carried out in two cases[2]. By 1951 ten more surgically treated cases are reported by Gross and Neuhauser[7]. All survived surgery and there was complete disappearance of the symptoms that had existed.

Symptoms

Aberrant right subclavian artery is often asymptomatic or associated with only mild dysphagia. However it occasionally results in marked dysphagia by its extrinsic pressure on the œsophagus, constituting the true dysphagia lusoria as described by Bayford[2]. It is noted that dysphagia is now thought by some to occur only when the origin of the abnormal vessel is aneurysmal[15].

Compression symptoms naturally vary according to the degree of compression and the course of the aberrant artery which varies somewhat as already described. Symptoms in children are described by Caffey[3] as follows:

> "The compression symptoms include paroxysmal or constant dysphagia, dyspnea (stridor, cough and hoarseness), cyanosis, retraction of the head and sometimes pain in the upper thoracic segments and the arms. These symptoms are all characteristically exaggerated during feedings and attempts at swallowing. The similarity of this clinical picture to that of so-called thymic obstruction is striking — in many recorded cases, aortic arch obstruction has been erroneously diagnosed thymic obstruction and so treated until the lesions in the aortic arch were demonstrated at necropsy or at surgical exploration of the mediastinum . . . "

Caffey's comments on the so-called thymic obstruction impress one as being of some importance. One wonders how many cases of aberrant right subclavian artery may have been treated as the so-called enlarged thymus syndrome. Perhaps roentgenologists should investigate all such cases more thoroughly.

Other symptoms have also been attributed to aberrant right subclavian artery. It has been suggested by Anson[1] that such changes as irregularity of radial pulses, enlargement of thoracic duct and symptoms like those of the scalenus anticus syndrome might be produced by aberrant right subclavian artery.

One example of the serious consequences is the early case reported by Bayford in 1789 (quoted by Stauffer and Pote[15]) in which dysphagis accompanied by a sense of suffocation was prominent since childhood and the patient died of inanition in her 61st year. Two other fatal results are mentioned by Gross and Ware[8]. One patient died of haemorrhage as a result of a bone sticking at the site of pressure. The other, a child, died of acute respiratory distress from food lodging in the œsophagus where the vessel crossed. More recently there has been reported a case, a four months old infant, in which striking relief of severe symptoms was obtained by surgery.

Diagnosis

That the roentgen diagnosis of aberrant right subclavian artery has become well established is shown by a number of cases (at least twelve) with typical roentgen signs that have been treated by surgery[7,13]. Gross and Ware[8] make the statement that barium visualization of the œsophagus can detect this abnormality with great accuracy. Copleman, already noted as apparently the first writer in American literature to diagnose aberrant right subclavian artery in the living writes:

> "In spite of the absence of operative or autopsy proof, the evidence in favour of this diagnosis seems incontrovertible

after a comparison with the cases and anatomic specimens published in literature."

Further experience has confirmed this opinion and now it may be stated with confidence that fluoroscopy or roentgenograms alone are quite sufficient to establish the diagnosis. Tracheobronchograms may give added information but are usually not necessary. Angiocardiography may be of value although findings may be difficult to interpret[10] and it is probably not often necessary as simpler methods suffice[11].

Further diagnostic proof of the exact nature of the characteristic pressure defect in the œsophagus is offered by Raphael and Schnabel[14] in 1952 by the use of a radiopaque catheter. This constitutes a new method of demonstrating an aberrant right subclavian artery by the introduction through the brachial artery of a radiopaque catheter. This method is thought by the writers to be less dangerous than angiocardiography. In their illustrations the thin catheter is seen lying along the oblique furrow in the œsophagus caused by the aberrant right subclavian artery, thus proving beyond any question the exact cause and nature of the characteristic X-ray findings.

In making a differential diagnosis it is obvious of course that there are difficulties. The œsophageal defect produced by a posterior type of right aortic arch (Fig. 4) might be confused with that caused by the anomalous right subclavian artery. However there are important points of differentiation[13]. The posterior type of right aortic arch usually displaces the œsophagus to the left as well as anteriorly and if one studies the films carefully the arch itself can usually be distinguished at the exact site of narrowing. In the case of abnormal right subclavian artery one can see a normal aortic arch slightly to the left of the vertebral column, usually not at the site of the œsophageal defect. In aberrant right subclavian artery the defect is usually just above the arch (case 1, Fig. 3) but may be lower[4]. It is smaller than the posterior defect produced by a posterior right aortic arch[13]. In all these cases actual anterior displacement of the œsophagus is less than that usually seen in posterior right aortic arch and the defect is smaller. The typical oblique defect produced by an aberrant right subclavian artery is readily seen in the anteroposterior projection if the barium is not too dense and if the amount swallowed is not too large. The defect is also well seen in the right anterior projection, preferably with patient upright. In the right anterior oblique projection the defect is seen to be on the posterior wall of the œsophagus that is, when the artery passes posteriorly as it usually does, and the defect is anterior to the œsophagus if the aberrant artery goes between trachea and œsophagus. In all these cases the anomalous vessel has been behind the œsophagus. It is to be noted that a double aortic arch may produce somewhat similar findings. The latter may result in constriction of both trachea and œsophagus. This combination of posterior œsophageal compression and an anterior tracheal defect (with the absence of a demonstrable mediastinal mass) according to Gross and Neuhauser[7] is almost certain proof of some sort of an encircling vascular ring.

Much useful information on various aortic arch anomalies is to be found in the writings of Anson[1], Brean and Neuhauser[2], Copleman[4], Fray[5], Gross and Ware[8], and Neuhauser[13]. A good schematic representation of the more important vascular rings is given by Lubert and his associates[12].

Treatment

Treatment of aberrant right subclavian artery is surgical when symptoms are severe or persistent. It has been found possible to abolish dysphagia by severing the artery and removing it from behind the œsophagus. This can be done without serious impairment of blood flow to the arm because of good collateral circulation[7,8]. Cases that are asymptomatic or have only slight symptoms do not warrant surgical treatment. It is to be kept in mind that symptoms such as dysphagia may increase as the patient gets older due to the greater rigidity of the artery[7].

Report of Cases

Five cases of aberrant right subclavian artery are briefly summarized:

Case 1. Female, age 43. Fig. 3. Chief complaint: Choking sensation after meals. Physical examination was essentially negative except the patient had been told by physician that blood pressure was 10 mm. higher in the right arm than the left. Roentgenological examination showed the typical spiral band like filling defect in the œsophagus. In this case it was slightly above the arch of the aorta.

Case 2. Female, age 36. Patient gave a history of some difficulty in swallowing for three days prior to admission to hospital. Roentgenological Diagnosis: An oblique band-like defect was found in the œsophagus at about the level of the aortic arch.

Case 3. Female, age 31. Patient complained of burning sensation in substernal region, lump in throat and slight nausea. Physical examination was essentially negative.

Roentgenological Diagnosis: In this case the spiral filling defect in œsophagus was slightly below the aortic arch.

Case 4. Female, age 19. Patient was admitted for examination of gastro-intestinal tract for the pain in epigastrium and right lower quadrant.

Radiological Diagnosis: Oblique filling defect was found in upper part of œsophagus typical of aberrant right subclavian artery. In this case the aberrant right subclavian artery was probably not causing symptoms.

Case 5. Male, age 25. This patient had a multiplicity of complaints and the roentgenological findings of aberrant right subclavian artery may or may not have been causing symptoms although on fluoroscopic examination there was apparently a moderate degree of dysphagia.

Summary and Conclusions

Five cases of aberrant right subclavian artery diagnosed by roentgen methods are presented. Anatomy, history, symptoms, diagnosis and treatment have been briefly reviewed. The importance of adequate roentgen examination of the œsophagus in roentgen cardiology and in gastro-intestinal studies is obvious. Further, it is suggested that examination of œsophagus should be done in all cases presenting symptoms of so-called thymic obstruction, or chronic tracheobronchitis, or in cases of repeated attacks of pneumonia. The fact that five cases have been found from 1950 to 1952 by one observer indicates that aberrant right subclavian artery is by no means rare. Its diagnosis has assumed importance following advances in surgery making successful treatment possible when indicated.

The characteristic roentgen findings described enable one to make the diagnosis in the living with great accuracy.

In discussion following presentation of this paper, Dr. W. L. Sloan of Vancouver reported another very interesting case of aberrant right subclavian artery. A young woman of 35 experienced two almost fatal haemorrhages. Several gastro-intestinal series done in hospital and two thorough exploratory operations failed to disclose the cause of the bleeding. Subsequent to this examination œsophagoscopy revealed some blood in the upper œsophagus without evidence of any focal bleeding point. The patient is now well.

Following the meeting Dr. Sloan was kind enough to send me his roentgenograms. These illustrate beautifully the typical spiral defect in the œsophagus caused by an aberrant right subclavian artery.

Since this paper was written another case of aberrant right subclavian artery has been found during fluoroscopy of the œsophagus as part of the examination of the gastro-intestinal tract. The patient a women of 59, a teacher, had no symptoms referable to the œsophagus. The typical spiral defect is well seen in films taken.

This brings the total number of cases found by one observer up to six and an additional case reported by Dr. Sloan during the discussion brings the total of new cases found recently up to seven.

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THE RADIOLOGIST AND ATHLETIC INJURIES *

EVERETT F. CRUTCHLOW, O.B.E., B.A., M.D., C.M. †

The radiologist plays a very important part in the diagnosis of injuries in athletes. His role is even more important than the one he plays in every-day life in the diagnosis of the routine injuries. No athlete has a minor injury. Every injury which he suffers interferes with his competitive ability, and whereas this may not be very important in amateur sports, it does assume great importance in professional sport where the athlete's livelihood depends upon his performance.

Radiology is particularly important in diagnosing the type of injury which an athlete receives, because all of the injuries occur during competition when the competitors are in an unusually high state of excitement, and they have a very high pain threshold which lasts up to 24 hours subsequent to the contest in which they engaged. We have learned by experience that the ordinary clinical signs and symptoms associated with bone and joint injury are less sufficient in the diagnosis of injuries in athletes than they are in injuries of the average patient. With this in view, we X-ray all injuries associated with joints, not only to find evidence of recent injury, but also to find evidence of previous trauma.

Bimalleolar fractures of the ankle, compression fractures of cervical vertebrae and severely comminuted fractures associated with the head of the radius have been surprisingly demonstrated on many occasions. When one examined the athletes immediately after the game, one would never have suspected that they had sustained such severe injuries.

This present paper is a survey of 1,112 radiographic examinations of injuries in competitive sport. This does not by any means comprise all of the injuries which have come to our department for we have excluded those associated with the winter sports, such as skiing and tobogganing. The vast majority, almost 96% of the cases, which we shall discuss are those drawn from the files of the Athletics Board of McGill University, from the Canadiens' Hockey Team and from the Montreal Football Club. They comprise, not only amateur, but professional sport as well. We have not found any significant difference in the injury rate in the two types of competition.

In our series, 396 (35.5%) showed evidence of recent trauma or old trauma, and 715 (64.5%) were negative. So it can be appreciated therefore, that while there may be a tendency to criticise the too frequent radiographic examination of the athletes for injuries, our percentage of positive findings is only approximately 15% below our over-all percentage of positive findings in the Department of Radiology at the Western Division of the Montreal General Hospital.

When we look at the attached chart, there are many interesting facts which confront us. The most common fracture is of the nasal bones, and considering that this is a very prominent part of our anatomy, it is not unusual that it should be broken most frequently. Fractures of the maxilla and of the mandible, all of which, incidentally, have occurred in hockey, as well as the two fractures of the skull, are relatively infrequent in our present series.

The next most common site of injury is of the shoulder, and as the majority of our patients are engaged in body contact sports such as hockey and football, this is not an unusual finding. Actually with the marked improvement in shoulder pads, the incidence of minimal and complete separation of the acromio-clavicular joints has decreased in the last two years, and the majority of our cases occurred prior to that time.

As far as the upper extremity is concerned, an interesting injury which is becoming more and more prevalent is a fracture associated with the phalanges involving the interphalangeal joints. The seven cases which we have do not indicate all of the cases that have occured in the teams with which we are associated, because many of these players never came to the department for X-ray. However, the persistent soft tissue swelling associated with these fractures and the persistent pain over long periods of time, make this a very disabling injury. This is caused, in my opinion, by the change in the shape of the football and with the increase in forward passing, where the player holds his hands up in the air to catch, or not completely catch, a fast moving spherical object.

You will note the relative frequency of fractures of the scaphoid, as compared to the fact that there is only one Colle's fracture. The Colle's fracture is not an injury asso-

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† *Consultant Physician McGill Athletics Board.*

1112 Radiographic Examinations of Injuries in Competitive Sport

Evidence of Recent Trauma	191 — 35.5%
Evidence of Previous Trauma	206
Negative	715 — 64.5%

Most Frequent Injuries According to Region
Shoulder and Upper Extremities.

Minimum Separation of Acromio-Clavicular Joint	15
Fracture of first metacarpus	10
Chip fracture of phalanx	7
Fracture of scaphoid bone	6
Sub-coracoid dislocation of humerus	5
Sterno-clavicular dislocation	4
Fracture ulnar styloid process	4

Pelvis and Lower Extremities.

Fracture lateral malleolus	7
Fracture shaft of fibula	6
Bi-malleolar fracture, posterior and lateral	4

Axial Skeleton.

Fracture transverse process of lumbar vertebrae	10
Compression fracture cervical vertebrae	2
Compression fracture dorsal vertebrae	2

Skull and Face.

Fracture nasal bones	34
Fracture of maxilla	5
Fracture of mandible	4
Fracture of skull	2

Thorax and Soft tissues.

Myositis Ossificans	7
Fractured Ribs	2

Unusual.

Refractured clavicle	2
Refractured first metacarpus	1
Colle's fracture	1
Humerus	1
Radius (shaft)	1
March fracture	1
Pneumothorax	1

No Fractures.

Pelvis
Femur
Bodies of Lumbar vertebrae
Ulna (shaft)

---

ciated with the age group, which is 18-26 years, taking part in competitive sport, and this is borne out by the statistics.

Our ankle injuries are all comprised of fractures associated with the lateral malleolus, and our bimalleolar fractures are always the lateral malleolus and the posterior malleolus. At the time this record was compiled, we did not have a single fracture associated with the medial malleolus. The fractures of the lower one-third of the shaft of the fibula are relatively common. We have no records of fractures of the superior portion of the shaft of the fibula.

As far as the axial skeleton is concerned, the most common type of injury is a fracture associated with the transverse process of the lumbar vertebrae. Compression fractures occur in the cervical vertebrae and in the dorsal vertebrae, but there are no records of compression fractures associated with the lumbar vertebrae.

A relatively common finding is myositis ossificans. This follows a severe so-called "Charley horse". One of our most difficult problems is to prevent the initial mishandling of soft tissue injuries which will produce more and more haemorrhage in the severe injuries and ultimately lead to myositis ossificans. Four persistent cases, which we had, responded quite readily to radiation therapy.

We have had only two cases of fracture of the ribs, one of which was associated with a pneumothorax in a boxer. He received his injury in the first round, completed a normal five round fight, and did not consult us until well on into the early hours of the next morning — another example of the high pain threshold in athletes. Fracture of the clavicle in this age group is relatively uncommon. Fractures of the humerus and of the shafts of the radius are most uncommon. We have no record of fractures of the pelvis or of the femur or of the shaft of the ulna.

The appearance of duodenal ulcers in members of the coaching staff can also be classed as an athletic injury. We have had only one and he complained of epigastric pain prior to a contest in which his team was engaged. A barium meal demonstrated an ulcer crater, which completely healed up in a matter of two weeks under therapy with no residual deformity of the duodenal bulb. We have since seen this coach on five subsequent occasions and on three, we have demonstrated a central duodenal ulcer crater, which has responded to therapy.

X-rays are taken of all knee injuries. Cases with a history of previous meniscus trouble invariably reveal small hypertrophic arthritic changes associated with the knee joint. Routine arthrograms with urokon are now made of all knee injuries in order to exclude meniscus damage. Injuries associated with the knee remain the most disabling and present the biggest problem of all our athletic injuries.

(Note: This paper is a preliminary review of records and will be followed in the near future by a more complete monograph of the diagnosis and treatment of all athletic injuries.)

X-RAY DOSAGE DISTRIBUTION IN LIMITED MEDIA *

L. G. STEPHENS-NEWSHAM, PH.D.
J. A. R. CLOUTIER, M.SC.
Montreal, Quebec

Introduction

All published tables of central axis depth dose data have been prepared from measurements made on phantoms sufficiently large to avoid any effects due to boundaries. The most recent and complete set of such data has appeared in the British Journal of Radiology[1] and is based on measurements made by several investigators who used large water phantoms and small dosimeters.

Since anatomical forms are limited in size, an attempt has been made to investigate the effect of limiting the size of the phantom on the central axis depth dose. Cylindrical phantoms have been used since these approximate more closely anatomical forms than solids with plane parallel surfaces.

Several investigators have studied the effect on exit dose due to reduction in thickness of the phantom. Clarkson and Herbert[2] used phantoms with parallel faces and varied the thickness. The exit dose was found to fit a relation:

$$\text{Exit Dose} = \frac{D_d + D_o}{2}$$

Where D_d is the depth dose at the exit surface as obtained from standard depth dose tables and D_o is the primary dose, this indicates that the percentage of radiation scattered forward is equal to that scattered back. Quimby[3] investigated phantoms of limited size and found no essential departure of the depth dose from that in large phantoms, provided that the phantom was larger than the beam.

For radiation in the range of h.v.l. 1.0 to 2.0 mm. Cu., the scattered radiation is primarily forward. However, multiple scattering occurs so that inside the scattering medium the contribution to the dose at any point due to scatter will be roughly the same from all directions. Consequently some variation of the depth dose from that in a large phantom might be expected if any appreciable portion of the X-ray beam lies inside the scattering medium or passes through it. The amount of reduction in scatter is difficult to calculate at this energy range and the effect can only be measured.

Experimental Methods

Cylindrical water phantoms were used having diameters of 8, 12, 15 and 20 cm. These were constructed of washed X-ray film mounted in lucite frames which gave thin-walled water equivalent containers which could be filled with water. The X-ray beam was collimated by three different cones, 5 x 5 cm, 6 x 8 cm. and 10 x 10 cm., and was produced by a 210 KV constant potential machine with filtration to produce a beam quality of either 1.0 or 2.0 mm. cu. h.v.l. The beam was directed into the side of the phantom, along a diameter.

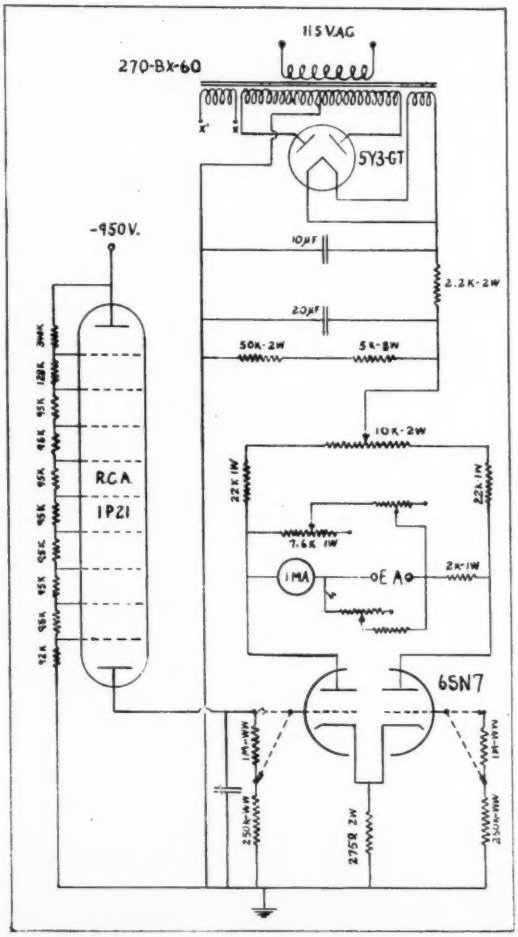

Fig. 1

*Presented at 17th Annual Meeting, Canadian Association of Radiologists, Quebec City, Jan. 13-15, 1954.

Dosage distribution was measured with a special scintillation dosimeter. This had a small scintillating crystal on the end of a 9 inch lucite "light pipe" which conducted the light from the crystal to a 1P21 photomultiplier. The current through the latter was measured by a vacuum tube voltmeter circuit and recorded on a chart milliameter, giving a current of 0.025 ma for 1 "r" per minute. The circuit is shown in Figure 1. The crystal was only 1.9 mm. in diameter and 4 mm. long. In order to make its response "air equivalent" it was constructed of a combination of Anthracene and Calcium Tungstate whose relative proportions were chosen empirically to make the response proportional to that of a Victoreen thimble chamber over a range of X-ray quality. The final arrangement was a crystal made of two cylinders end to end. The Calcium Tungstate cylinder was 2.4 mm. long and the Anthracene cylinder was 1.6 mm. long. The latter was nearest the photomultiplier. It was possible to make the response constant within ± 4% from .44 mm. Cu. to 2.0 mm. Cu. h.v.l. Below this the response fell off fairly quickly due to the .4 mm aluminum reflecting cap surrounding the crystal. The instrument proved to be quick to respond and had a linear response. There was, however, a phosphorescence lasting for several seconds which made it unsuitable for rapidly varying X-ray intensities.

The dosimeter was mounted on a stand having a track, allowing it to be moved along the axis of the beam. A pair of Selsyn motors were used to move it to any desired position, from outside the room.

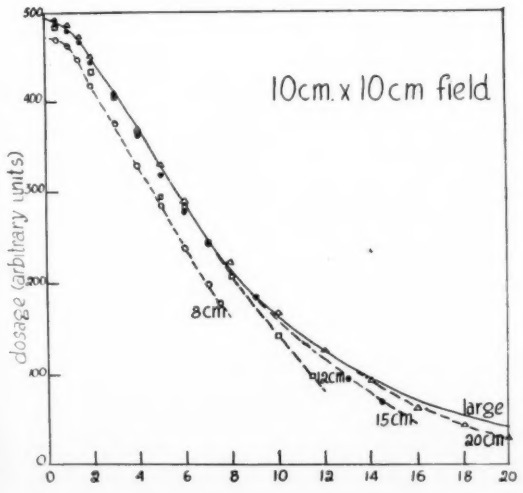

Fig. 2

Results

Measurements were made along the central axis of the X-ray beam for each of the four phantoms as well as in a large rectangular water tank used for comparison. Results for the 10 x 10 cm. field are plotted in Figure 2. Similar results were obtained for the other field sizes though the deviations of the depth doses from one another were much less.

The deviation of the depth doses from those in the large phantom are most noticeable when the phantom dimensions are less than those of the beam. They are not negligible for other sizes of phantoms and Table I gives some of the deviations in exit dose from that predicted by the large phantoms. This Table gives the error, expressed as per cent of the skin dose, and as seen the greatest error occurs for the smallest phantom and largest field, amounting to as much as 14 per cent.

TABLE I.

FIELD SIZE	% ERROR IN EXIT DOSE			
	8 cm.	12 cm.	15 cm.	20 cm.
5 x 5 cm.	— 2	— 3	0	0
8 x 6 cm.	—10	— 3	— 2	0
10 x 10 cm.	—14	— 8	— 4	— 3

Some error will result in the depth dose at any given point in the scattering medium. Table II gives the errors in depth dose at the centre of the phantom. These are only important when the field size is greater than the size of the phantom and may amount to 10% or so.

TABLE II.

FIELD SIZE	% ERROR IN MID-POINT DOSE			
	8 cm.	12 cm.	15 cm.	20 cm.
5 x 5 cm.	0	0	0	0
8 x 6 cm.	— 8	— 1	0	0
10 x 10 cm.	— 9	— 2	— 2	0

Conclusions

The errors in depth dose and exit dose are only important when the diameter of the phantom is the same or less than the diameter of the X-ray field. Errors in exit dose may amount to 10 or 15% for a 10 x 10 cm. field. Other depth doses may be 10% lower than depth dose tables predict if the field is smaller than the phantom.

Acknowledgements

This work was supported by a grant from the National Cancer Institute.

The authors wish to express appreciation to Dr. C. B. Peirce, Radiologist in Chief, and Dr. J. Bouchard, Radiologist, Royal Victoria Hospital, for their interest and help in this work.

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2. Clarkson, J. R. and Herbert, R.J.T. British Journal of Radiology, *21*, 494, 1948.

3. Physical Foundations of Radiology, Glasser, Quimby, Weatherwax and Taylor Hoeber, 2nd Ed. 1952, p. 282.

POSITIONS AVAILABLE

A vacancy exists for a certified English-speaking radiologist to take charge full time of the X-ray epartment of a 121-bed general hospital in Quebec City. New 150-bed hospital under construction. Terms on application. Apply to: Administrator, Jeffery Hale's Hospital, Quebec City, Que.

Position Vacant — Radiologist wanted, 600-bed general teaching hospital — Department recently expanded. Basic salary plus percentage of gross revenue. Sister Superior, Ottawa General Hospital, Ottawa, Ont.

Diagnostic radiologist wanted for position as full time assistant. Address enquiries to: Superintendent, Regina General Hospital, Regina, Saskatchewan.

Wanted an assistant for active diagnostic and therapeutic radiological practice in Port Arthur, Ontario. Applicants to have certification with Royal College of Physicians and Surgeons of Canada as specialist in Diagnostic Radiology and should be fully qualified to practice in the Province of Ontario. Address enquiries to: Dr. W. A. Hargan, General Hospital, Port Arthur, Ont.

Appointment available in Diagnostic Roentgenology in 165-bed general hospital. Appointment to commence January 1st, 1955. Apply to: Administrator, General Hospital, Pembroke, Ont.

MEETINGS

The schedule of meetings for the Eighteenth Annual Meeting of the Canadian Association of Radiologists to be held at the Chateau Laurier, Ottawa, January 10th - 12th, 1955, is as follows:

Monday January 10th:		
Registration	All Day	Convention Hall
Meeting of Council	9:30 A.M.	Salon D
Meeting of Council	2:00 P.M.	Salon D
Annual Meeting	8:00 P.M.	Convention Hall
Tuesday, January 11th:		
Registration	All Day	Convention Hall
Scientific Session	9:00 A.M.	Convention Hall
Scientific Session	2:00 P.M.	Convention Hall
Reception	6:15 P.M.	Drawing Room
Annual Dinner	7:15 P.M.	Banquet Room
Wednesday, January 12th:		
Scientific Session — Diagnostic Radiology	9:00 A.M.	Convention Hall
Therapeutic Radiology and Radiation Physics	9:00 A.M.	Salon D
Scientific Session	2:00 P.M.	Convention Hall

The Seventh Annual Mid-Winter Radiological Conference, sponsored by the Los Angeles Radiological Society, will be held at the Ambassador Hotel in Los Angeles, California, Saturday and Sunday, February 26th and 27th, 1955. Conference reservations may be made through the chairman, Dr. Richard A. Kredel, 65 North Madison Avenue, Pasadena, California. Hotel reservations should be made as soon as possible through the Convention Manager of the Ambassador Hotel.

The Eighth International Congress of Radiology will be held in Mexico City, January 22nd - 28th, 1956. Correspondence should be addressed to the Congress Office at Calle del Oro 15, Mexico 7, D.F., Mexico.

In Memoriam

It is with deep regret that the Canadian Association of Radiologists records the deaths of four senior radiologists during 1954.

CAMPBELL, Clarence Gordon

December 7th, 1901, Darmouth, Nova Scotia
M.D. — Dalhousie University 1924

HYNES, John Albert Story

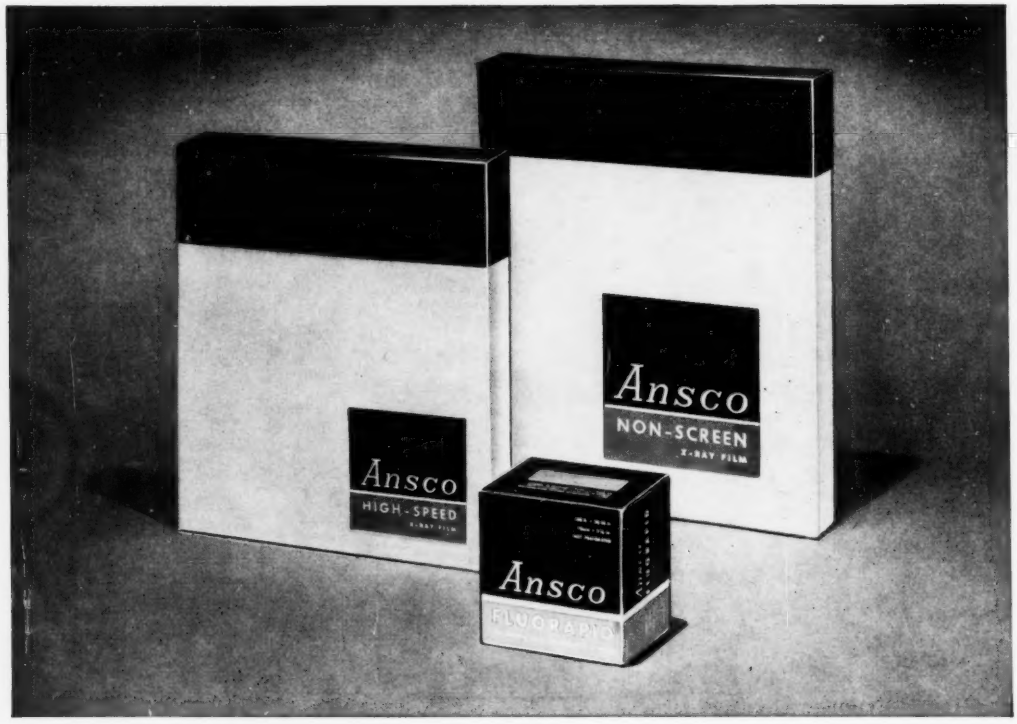
1892, Kensington, Prince Edward Island
M.D.,C.M. — McGill University 1922

KRUGER, William Cecil

May 9, 1901, Lacombe, Alberta
M.D. — University of Toronto, 1923

PERRON, J. Edmour

July 8th, 1887, Sainte Jeanne de Neuville, Quebec
Université de Laval, 1915.



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